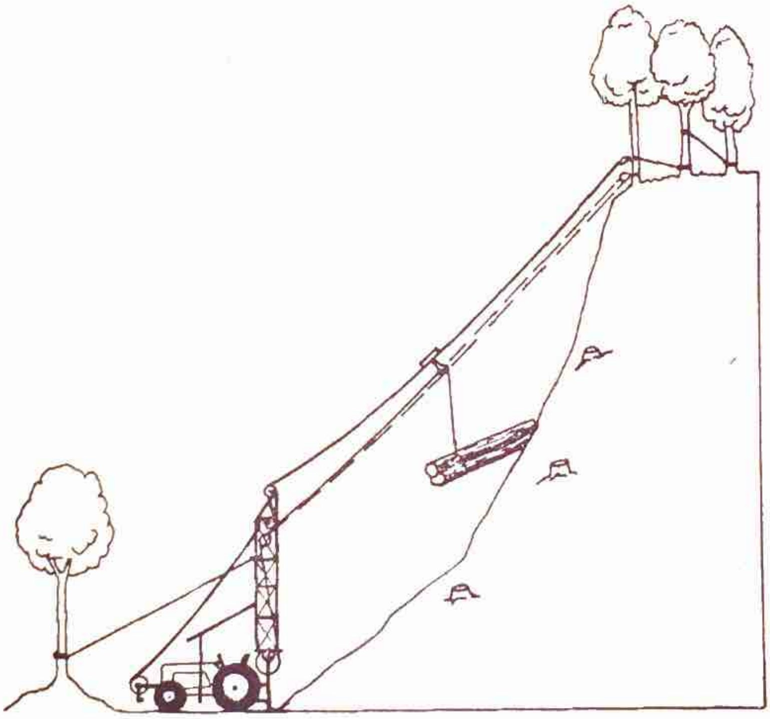
VERMONT

CABLE YARDER

PROJECT

A COOPERATIVE DEMONSTRATION



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VERMONT DEPARTMENT OF FORESTS, PARKS AND RECREATION

funded by:

U.S. DEPARTMENT OF ENERGY

with assistance from:

U.S.D.A. — FOREST SERVICE

Northeast Area State and Private Forestry

Northeastern Forest Experiment Station — Burlington, Vermont

Green Mountain National Forest

UVM

Extension Service

consultant:

WOODLAND FUELS, INC.

Special thanks go to John "Zeke" Hornick of the U.S. Forest Service, Washington Office. His efforts made this project possible.

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CHAPTER I: INTRODUCTION

by M. Brian Stone

The purpose of the Vermont Cable Yarder Project was to build and demonstrate to private landowners and the logging industry of the Northeast a cable yarding system capable of handling fuelwood and small commercial size timber economically, with minimal environmental impacts.

In Vermont, 73 percent of the commercial forest land is privately-owned, 12 percent is in public ownership, and 15 percent is held by industrial interests. The situation is similar to other Northeastern states.

Within these ownerships, logging conditions vary greatly. For example, steep slopes (+25%) have been variously estimated to make up 15–45 percent of the commercial forest land. In addition, other adverse site characteristics, such as swampy conditions and generally rough and rocky land, account for a significant portion of the forest land.

The Northeast has a large quantity of low-quality timber, suitable primarily for fuelwood, a situation which occurs in all areas and which is a hindrance to maximizing growth on quality stems. Existing systems for harvesting these overstocked stands of poor-quality trees tend to have limited efficiency due to high residual stand damage and the high capital cost for low product value. The proposed system of cable yarding offers a remedy for this condition.

Expanding demands for wood products, wood fiber, and biomass are predicted for the immediate and long-term future. To satisfy these demands, the logging industry will have to produce larger quantities of wood from the existing forest land base.

Many of the sites more difficult to harvest offer excellent potential for tree growth. But these sites often are unavailable for harvest because of the attitutdes of landowners concerned with possible logging damage to their land, the cost of reaching the sites, and limitations of existing harvesting equipment.

In recent years, interest has mounted in the use of cable yarders to resolve problems related to adverse logging conditions. Limited testing of equipment and various studies indicate that cable yarding would be useful in certain types of harvesting activities.

The Northeastern logging industry has been reluctant to invest in these systems though counterparts in western North America and Europe have made successful use of cable yarding to overcome site constraints in their forests.

The Vermont demonstration offered an opportunity to test a prototype cable yarding machine under northeastern conditions. The test data, collected over a six-month period, is summarized and analyzed in the following chapters of this report. The operation of the Vermont Cable Yarder has provided an example for the industry to follow through a method that may be practical in harvesting adverse forest sites.

Cable systems could make available for harvest many more acres which previously have been difficult to reach. Many of these acres have not been managed and are in need of thinning or stand conversion to obtain their maximum potential. In most cases, cable yarding systems create fewer environmental impacts on the forest than do conventional logging practices. This offers the land manager opportunities not previously available for improved management and economic return to the landowner.

Additional benefits may be derived by making more fuelwood available to the expanding market. (Vermont's consumption increased from 350,000 cords in 1978–79 to 430,000 cords in 1979–80.)

The Deparment of Forests, Parks and Recreation purchased the component parts of the cable yarder through the Vermont purchasing system. Most were stock items with 30–90 day delivery dates from receipt of purchase order. Some delays were encountered in items purchased from abroad.

Parts were delivered to the contractor for assembly and any special fabrication that was required, was obtained through contract.

The system includes skyline capability for uphill and downhill yarding with intermediate supports to provide for convex slopes. The system is powered by a 34-hp diesel engine through a two-speed PTO and gear reduction in the winch to give a maximum mainline pull of more than two tons.

All equipment associated with the cable yarder is the property of the U.S. Forest Service, Northeastern Area State and Private Forestry.

A four-member crew was trained and provided by the contractor. Flexibility was maintained on crew size to determine the most efficient combination of manpower.

The cable yarder was publicly-demonstrated on four sites, two on state forest land, and one each on private land and on the Green Mountain National Forest. The sites offered a diversity of forest conditions to illustrate the machine's capabilities.

The following chapters of this report provide a technical description of the project and the results of the effort.

CHAPTER II: SYSTEM DEVELOPMENT

by E. Gerry Hawkes

The recent demand for fuelwood has created a new market for the small, rough and rotten hardwoods which constitute a major part of Vermont forests. This market, in turn, has provided an opportunity for forest managers to upgrade the quality of the forests. The question is how can they harvest these stands economically while minimizing residual stand damage and retaining the multiple-use forest management goals of the woodland owners.

Large size and high horsepower are principal factors that make skidders damaging when used to extract thinnings. High machine purchase and operating costs may require skidder operations to overcut or to take expedient actions which may have serious long-term effects on residual stand quality and growth. Even with careful operation, it is difficult to avoid soil compaction and disturbance on main skid trails.

Small crawler tractors often can be maneuvered more easily for the extraction of thinnings than can skidders, but they are slow and expensive to operate.

Light, four-wheel drive tractors in the 15–50-hp range are becoming commonplace in thinning operations. These tractors, often equipped with a three-point hitch winch, can be operated with little stand or site disturbance, but because of their light weight and small size, turn volumes are low and cycle times are long.

Horse skidding has the potential for being the least damaging of the yarding methods and is preferred by many woodlot owners, but the disadvantages are low skid volumes, slow yarding speeds and plain hard work.

Timber yarding methods common to the Northeast generally involve ground skidding and, therefore, are subject to limitations imposed by terrain and ground conditions. Impediments, such as steep slopes, rocky ground, mud, and snow, are common and often can be severe. Combine these limitations with the necessity of economically extracting low-value material with minimal site disturbance and residual stand damage, and the task becomes formidable.

A yarding method that would minimize ground skidding and the movement of vehicles in the forest seemed to offer the best solution. Skylining with cables appeared to be the most favorable alternative. At first, experiments were conducted with an inexpensive live skyline, gravity yarding system which allowed loads free descent to the landing. Residual stand damage and site disturbance with the gravity system was low, but its effective operation was limited to concave slopes within a narrow range of steepness above the designated landing. Needed was a relatively low-cost skyline system, which could yard safely, uphill or downhill, over any terrain.

SYSTEM DESIGN AND COMPONENTS

Woodland Fuels, Inc., of Woodstock, Vermont, designed and built the Vermont Cable Yarder. This is a double-drum yarder, using a standing skyline capable of moving timber 1,000 feet from the stump to a landing.

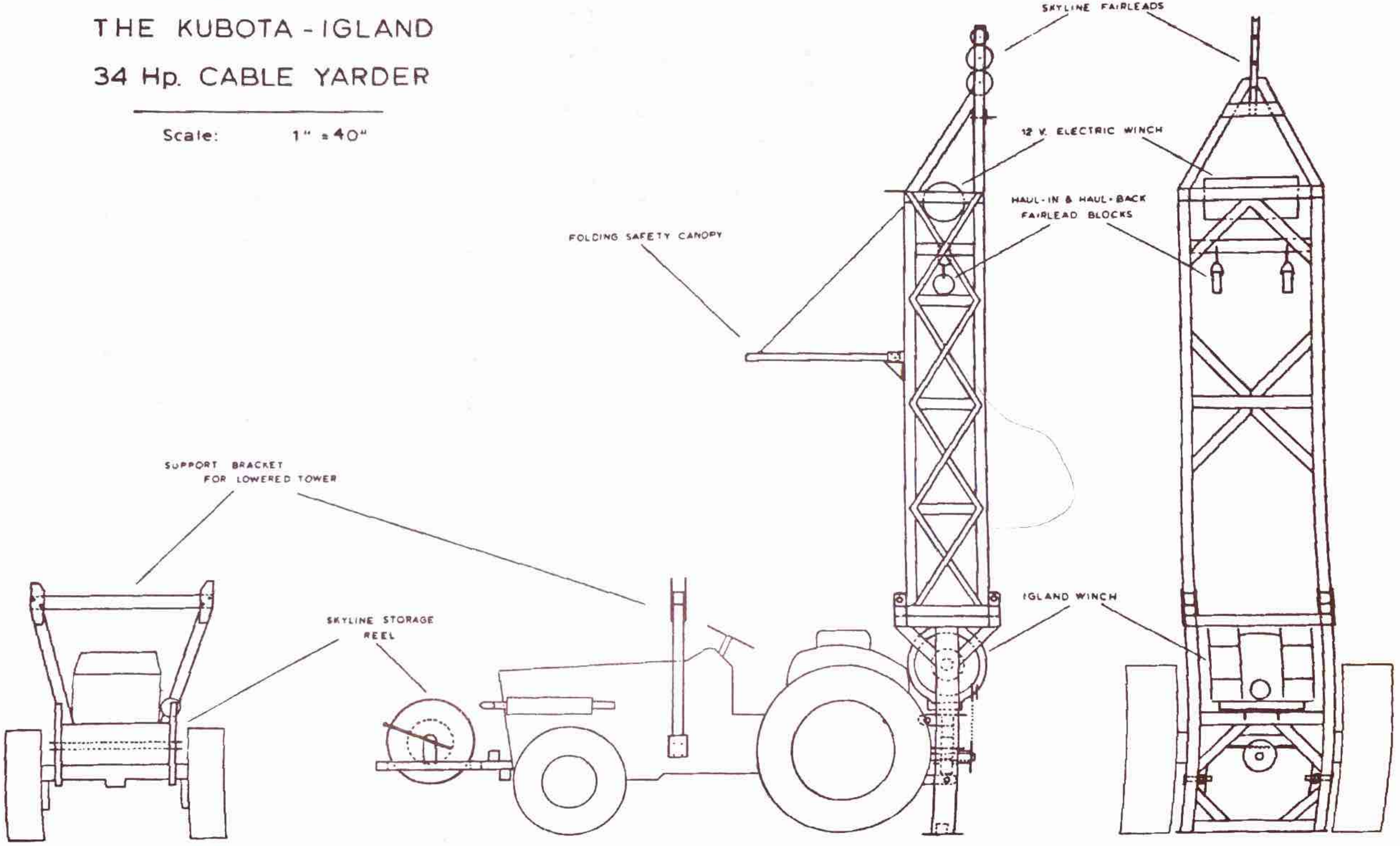
The major components of the yarder are:

1. Kubota Tractor (34-hp) Model L345DT.
2. Tower — 19.5 feet overall height.
3. Igland Winch, Model "Special 4000/2" Double-Drum; maximum line pull 8,000 lbs.
4. Skyline storage reel.
5. Skyline — 1,500 feet, ½-inch plastic impregnated cable.
6. Operating Lines — "Haul-In" and "Haul-Back", 2,000 feet, 5/16-inch plastic impregnated cable.
7. "Smith Timbermaster" Skyline locking carriage.

BASIC DESIGN OF

THE KUBOTA - IGLAND 34 Hp. CABLE YARDER

Scale: 1" = 40"



FRONT VIEW

SIDE VIEW

REAR VIEW

MARCH 1982

HAWKES

8. Intermediate supports.
9. Taglines — 200-foot lengths of 5/16-inch plastic impregnated cable.
10. "Smith Timbermaster" self-releasing choker and choker chains.
11. FM portable radios.
12. Miscellaneous rigging hardware.

Approximate cost of the components. . . $35,000.00

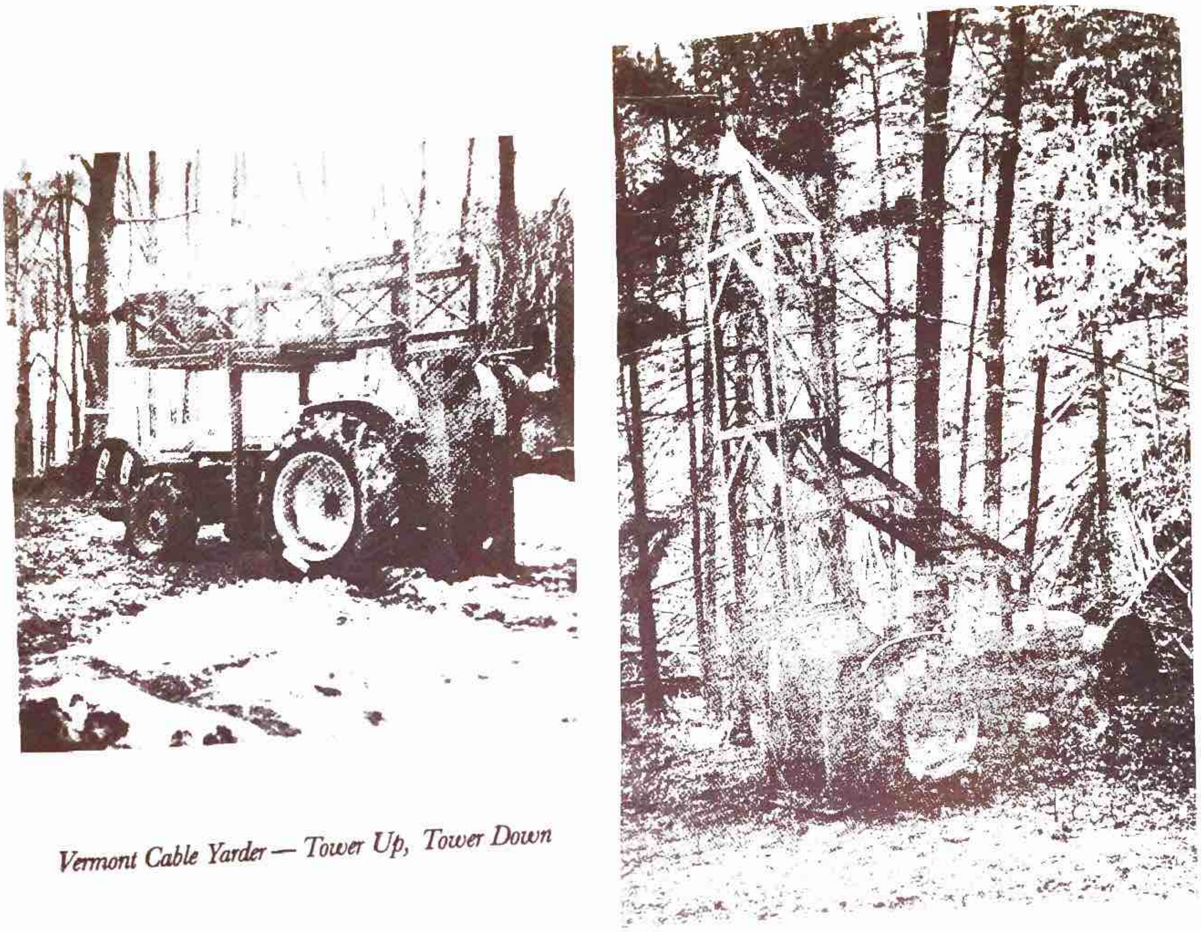
The 34-hp diesel, four-wheel drive, Kubota tractor provides power for the system. A model 4000/2, double-drum Igland winch, with capacity for 1,000 feet of 5/16-inch diameter cable on each drum, is mounted on the tower base and is powered by the tractor's PTO. The steel tower has an overall height of 19.5 feet above the ground. Fifteen hundred feet of ½-inch diameter skyline are stored on a reel at the front of the tractor. The operating lines control the movement of the skyline carriage which runs back and forth into the forest on the skyline. Communications between the yarder operator and the choker setters are by Motorola, two-way radios.

Both fuel and maintenance costs are low since the yarder remains stationary near the roadside, and only the 150-pound skyline carriage travels to and from the forest on a smooth, overhead line. Fuel consumption ranged from two to three gallons per day.

Allowing for 100 feet of lateral yarding to each side of the skyline, the Vermont Cable Yarder can reach out 900 feet with the 1,000 feet of cable stored on either of its winch drums. When necessary, an extra 200 feet of line may be clipped on to extend the reach of the haul-in cable. More than twice as much cable is needed for the haul-back as the haul-in because of the system's design (See Figure 2). Depending on the length of the skyline corridor, zero to seven 200-foot sections of cable (taglines) are added to the haul-back with snap-link connectors. The skyline always is anchored beyond its support tree (tail tree) at the far end of the skyline corridor, thus 1,500 feet of skyline are provided to insure sufficient length to reach suitable tail trees and anchors. All the skyline and working cables on the Vermont Cable Yarder are Macwhyte "PFV" thermoplastic impregnated wire ropes. The thermoplastic greatly increases the cable's resistance to crushing and abrasion, and its orange color makes it easy to see.

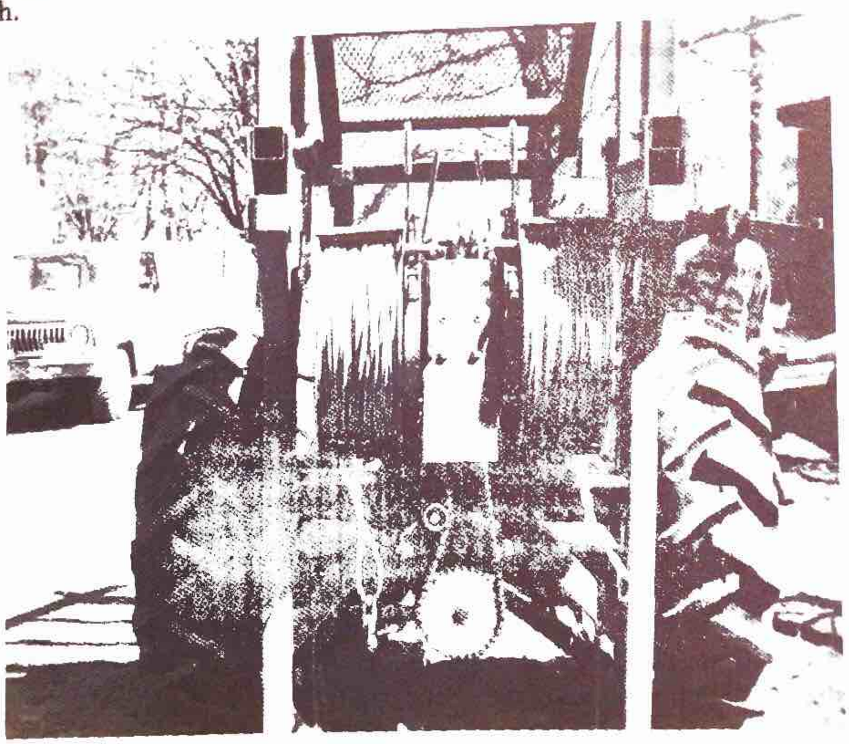
The tower and tower base on which the Igland winch is mounted were designed by Woodland Fuels and fabricated by Poma Aerial Tramways in Woodstock, Vermont. The tower base pins to the tractor's three-point hitch in the same fashion as a farm implement.

A quick disconnect drive shaft connects the PTO to the winch's chain drive so the tractor may be uncoupled quickly from the tower and winch, freeing it for other uses. Four heavy pins secure the tower in a vertical position above its base where it is anchored during operations by three ½-inch guylines. By removing the two pins on the side away from the tractor, the tower can be lowered down over the tractor using a 12-volt, Ramsey electric winch mounted near the top. As the tower is lowered, a safety canopy, with one end resting on the tower support bracket and the other end pinned to the tower (different than the basic design sketch), automatically folds up against the tower. When completely down, the tower and safety canopy rest on the tower support bracket, which is bolted to the middle of the tractor. With the lowered tower's weight supported by the bracket, the tower base can be lifted off the ground by the tractor's three-point hitch hydraulics, allowing the yarder to be driven to a new location. The Ramsey winch in the top of the tower serves both to raise and lower the tower and to control the tension of the standing skyline during yarding operations. Above the electric winch, the tower tapers to a point with three six-inch-diameter sheaves mounted vertically, one over the other. Over the lowest sheave passes the cable from the Ramsey winch, which is used to raise and lower the tower as well as tension the skyline. The middle sheave serves as a guide for the skyline as it is wound on or off the front-mounted storage reel. The top sheave acts merely as an idler. Just below the Ramsey winch are two fairlead blocks, through which run the working lines (haul-in and haul-back). They are spooled in and out from the drums of the Igland winch.



Vermont Cable Yarder — Tower Up, Tower Down

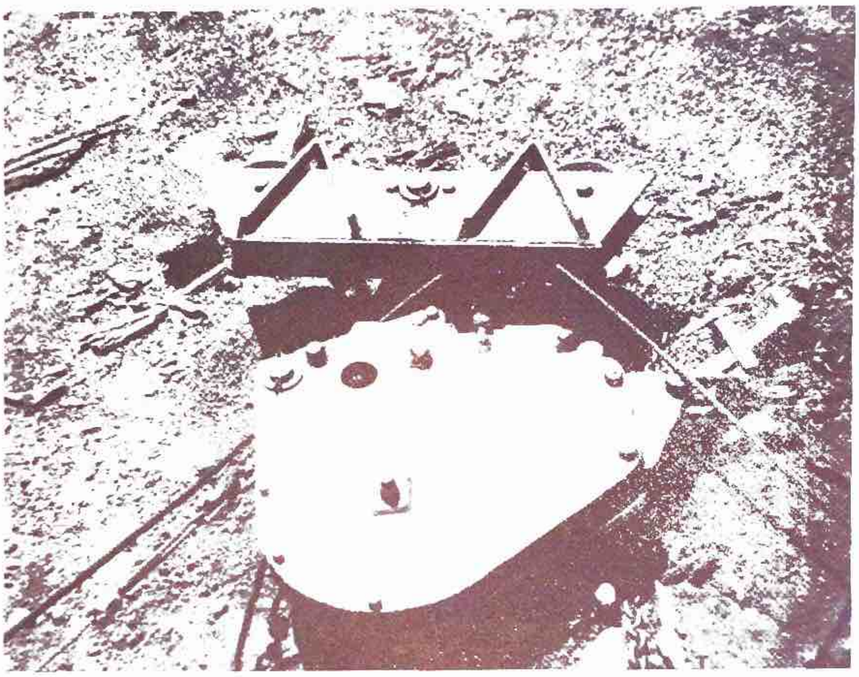
The Igland winch is secured to the tower base by four heavy bolts which also serve to adjust the alignment of the winch and its chain drive. Each winch drum is controlled by a hand activated clutch and brake, and is well shielded to prevent accidental operator contact with the spooling cables. The theoretical capacity of each drum is 1,300 feet of 5/16-inch diameter cable, but 1,000 feet is the practical limit for smooth operation. When equipped with 100 or 200 feet of 3/8-inch diameter cable on each drum and fitted with a butt plate on the rear of a 50-hp or larger tractor, this Norwegian-made winch also may be used for ground skidding in much the same fashion as a skidder mounted winch.



Igland Winch

At the front of the tractor, the wooden skyline storage reel is mounted on a tubular steel frame that can easily be slipped on or off the tractor. A steel shaft turning on two pillow block bearings serves as the reel's axle. This axle has fittings at each end to receive the hand cranks used in winding up the skyline.

The skyline carriage, purchased from Smith Timbermaster in Scotland, is capable of passing over intermediate skyline supports, and is equipped with an adjustable load locking device. When a turn is winched up to the carriage, the lock engages a locking ball on the line and the load is held up to the carriage without requiring tension in the working lines. This load locking feature makes for smoother, faster, more efficient operation with much less wear on the winch clutches and brakes. A trip shoe hung on the skyline near the landing releases the lock so turns may be lowered onto the deck.



Skyline Carriage

A self-releasing choker hook and choker chains also were purchased from Smith Timbermaster. This device releases the turn from the chokers as it is lowered onto the deck. The hinged bottom section of the self-releaser compresses upward, releasing a latch that allows one end of the chokers to fall free. The other end remains attached to the self-releaser to be pulled out of the deck by the working line and returned to the woods with the carriage.

Essential rigging hardware includes:

1. Corner blocks for changing the direction of the haul-back line at the back of a setting;
2. Seven, 200-foot-long tagline sections with snap link sets for extending the haul-back;
3. Nylon safety slings for securing corner blocks and cable clamps to trees without injury to the tree;
4. Intermediate skyline supports for supporting skyline at an adequate height above the ground over long spans or convex slopes;
5. Bearer cables for suspending the intermediate skyline supports between trees;
6. Trewhella cable clamps for securing the ends of guylines and the skyline; and
7. Miscellaneous clamps, shackles and fittings.

Self-Releaser

Support equipment includes: an 8- × 12-foot trailer serving as a storage facility, maintenance shop and crew warming shack; a line firing bow; pre-rigging ropes, a 20-foot aluminum extension ladder; a tagline storage reel and stand; a two-ton come-along; and miscellaneous small workshop tools such as hammers, wrenches, and cable cutter.

CREW AND TRAINING

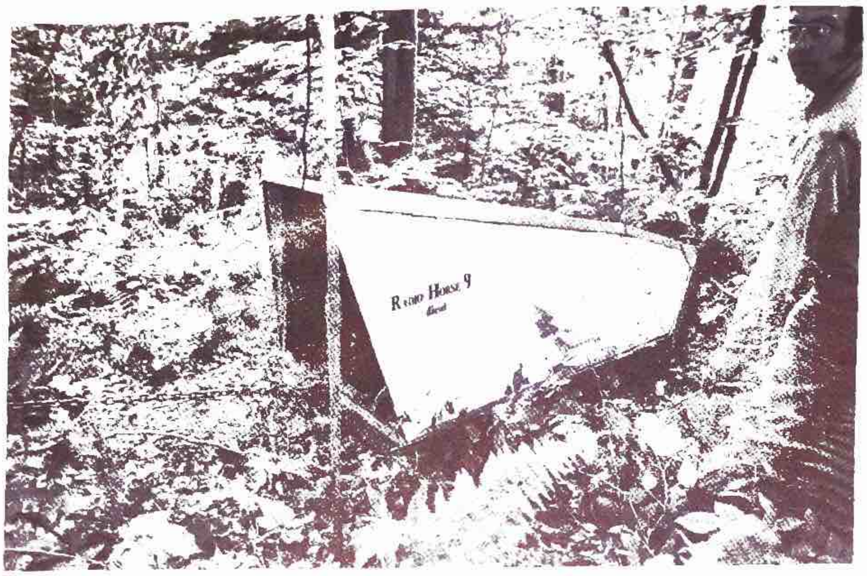
From among the job applicants, four enthusiastic young men were chosen to fill the positions of yarder operator, choker setter, chopper and chopper/choker setter. Their experience with chainsaws and logging operations ranged from virtually none to a year on a production logging crew. For an experimental/demonstration project such as this, it was felt that enthusiasm, intelligence, reliability, and a good educational background were the attributes needed in crew members. Undoubtedly, more logging experience would have boosted overall production, but more important, the crew was willing to take the time to develop new ideas and working techniques, travel great distances to demonstration sites, working long and hectic hours to keep the demonstrations on schedule, and to explain the system over and over again to the nearly 2,000 official and unofficial visitors.

Training began on April 5, 1982, with two feet of snow on the ground and blizzard conditions. During the worst days of high winds and snow, indoor sessions were held on chainsaw working techniques, chainsaw maintenance, principles of cable system operation, safety and first aid.

From the start of training to the end of the project, all crew members were required to wear hard hats with face screens and ear protection, safety pants with ballistic nylon pads, heavy boots and gloves while on the job.

Except for two days of indoor sessions, training was held at the first job site, chosen for the moderate terrain in the harvest area, the range in tree sizes and nearness to Woodland Fuels' base of operations. Initial instruction was given in corridor layout for skyline cable systems, felling patterns in relation to skyline corridors, directional felling, felling techniques, limbing and bucking.

Instructions were then given in the use of the "Radio Horse 9," a radio controlled bunching winch recently developed by Woodland Fuels. This winch was designed to decrease residual stand damage while increasing the payloads and reducing the hook-up times for conventional yarding equipment by bunching felled trees into easily accessible piles.



"Radio Horse 9"

A 16-hp Kubota/Igland cable yarder, designed and owned by Woodland Fuels, Inc., was used for the first six weeks of cable system training. Instruction covered set-up, rigging configurations, operating techniques, choker setting, take-downs and maintenance.

From the beginning of training and throughout the life of the project, crew members regularly rotated jobs so that all were familiar with each aspect of the operation. While this policy involved more training, it helped the crew to work better as a team and made the work much more interesting.

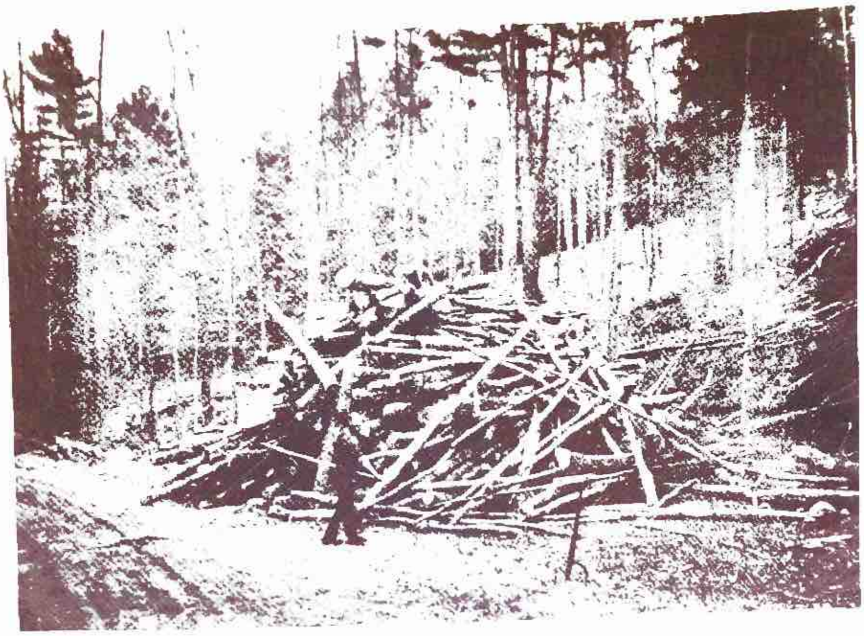
SITE SELECTION AND LAYOUT

The operation of the Vermont Cable Yarder is seldom limited by terrain or ground conditions. But, it is still important to select and lay out sites with care to keep operating costs down and insure that damage is not done to the residual forest stand, soil, streams, wildlife habitat, and aesthetics.

It is estimated that at least eight cords per acre of pole-size or larger firewood thinnings must be removed from a site to cover the costs of set-up and operation. As the value of the timber removed increases, less volume is needed per acre to reach the break-even point. During this project, a non-commercial thinning was done using the Vermont Cable Yarder with little damage to the residual stand. However, it should be brought to the attention of landowners, that if they desire this type of thinning, they will have to pay for it.

Adequate space should exist at roadside for landing the timber removed from the harvest site. A space as small as 10 by 20 feet is adequate for the decking of 10-12 cords of 20-foot wood under ideal conditions. If landing space is limited, plans should be made for moving the wood out promptly or enlarging the landings. Soft or wet landings will not be disturbed by the yarding and decking operations, but log trucks must have a firm surface within loader reach of the decks. Since decks are often made along a gravel road, there is normally little problem with log truck access.

Next, it must be determined if all the wood in the harvest area can be brought to the available landing space. If not, additional landings must be created, or a loader or a skidder employed to swing timber off an embankment or out of a roadway. For purposes of the project, there were enough suitable sites available with natural landings that little special landing preparation or landing support equipment was used. All timber within the harvest area must be within 900 feet of a landing, although in special circumstances the Vermont Cable Yarder can be rigged to reach out 200 additional feet.



Log Decks Along Road

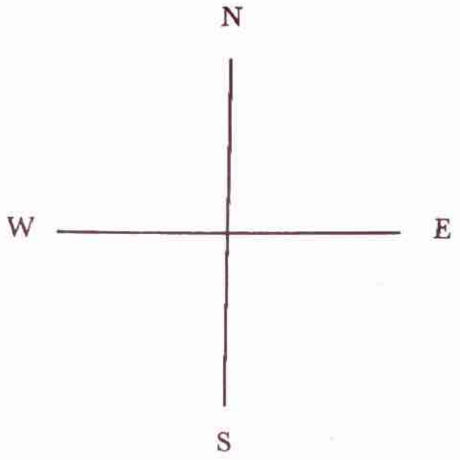
Once a harvest site has been selected, the boundaries of the harvest area should be determined and marked if necessary. Then, with a map of the harvest site, or by standing on the designated landings, preliminary locations of skyline corridors are noted and rough compass bearings determined. With knowledge of the approximate number and location of skyline corridors, yarder positions then may be selected. In some situations, one yarder position may serve several skyline corridors. Often, when space is restricted, the yarder is set up on top of a road embankment or tucked off the road between the trees on the same side of a road as the landings with the skyline and working cables reversing off a spar tree on the opposite side of the road.

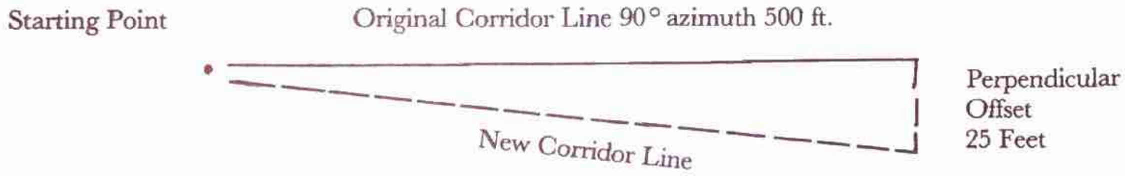
When the yarder positions have been chosen, the skyline corridors are carefully laid out, normally either as parallel lines running perpendicular from a road or as lines radiating from a single landing. In any case, the maximum distance between skyline corridors should range from 120 feet to 250 feet, depending on the terrain, density of the stand, ground conditions, and height of the skyline.

Using an accurate hand compass, a precise corridor bearing is run from the yarder or spar tree position across the designated landing and into the harvest area. Trees five feet to either side of the compass line must be cut. While running the compass bearing and flagging the line, slope distance measurements are made using an optical distance meter, a "hip-chain," or by pacing. Clinometer readings may be taken along with distance measurements, if necessary, for plotting a topographic profile of the corridor. The compass line is continued until the back of the harvest area is reached.

A suitable skyline tail tree must be at least 12 inches in diameter, alive and well-rooted, to support the skyline at a height of 15 to 40 feet above the ground and must be found on line in back of the harvest area. If there is any question as to the suitability of the tail tree, plans should be made to guy it. If no tail tree can be found on line, then the corridor must be shifted to line up with a suitable tree, and a new corridor line run back to the starting point. To avoid frequent trial and error in the rerunning of corridor lines, a hand-held scientific calculator may be used to quickly compute the exact bearing of the new line. This is done by dividing the distance offset from the original line to the tail tree by the length of the original line at the point of perpendicular offset, then pushing the "tan-1" button, which gives the degree difference between the old and new lines. This must be added to or subtracted from the back bearing of the original corridor line, depending on which side of the original line the offset was made.

Sample Calculations for Running a New Corridor Line Back to the Starting Point After Making an Offset




Starting Point
Original Corridor Line 90° azimuth 500 ft.
Perpendicular Offset 25 Feet
New Corridor Line

$\measuredangle$ = offset angle

Method for computing return azimuth of new corridor line:

$$\frac{\text{Offset Distance}}{\text{Original Line Length}} \times \text{Tan-1 (on calculator)} = \text{offset angle } \measuredangle$$

OR

$$\frac{\text{Offset Distance}}{\text{Original Line Length}} = \text{natural tangent of offset angle (use tables of natural tangents to find angle)}$$
(Surveyors Handbook)

EXAMPLE

$$\frac{25\text{ ft.}}{500\text{ ft.}} = 0.05 \text{ (natural tangent)} = 2°52' = \measuredangle$$

New Corridor line back azimuth = original corridor line azimuth
± calculated offset angle + 180°
(−360° when the sum is greater than 360°)

EXAMPLE

$90° + 2°52' + 180° = 272°52'$ back azimuth on new corridor line

If it is necessary to offset and rerun the corridor back to the starting point, the flagging must be shifted from the original line to the new line but it is not necessary to take any distance measurements on the new corridor. When returning to the starting point, it is noted where intermediate supports will be needed along the corridor and support trees are flagged.

Once the skyline corridors, tail trees, intermediate support trees, and anchor trees have been flagged out on the harvest area, the tree marking can begin. It is possible to lay out the site after the marking has been completed. But a much better job of marking and harvesting can be done if the marking takes into account the direction in which the trees are to be felled and removed and the effect of the 10-foot-wide skyline corridor.

SEQUENCE OF OPERATIONS

Before commencing with this section, it should be noted that many felling, bucking, and system techniques were tested during the course of this project. The techniques described are ones that evolved by the end of the project and are considered to be the best for most situations.

Prior to setting up the system, trees must be felled along the entire length of one or two, 10-foot-wide skyline corridors. In addition, any trees to be felled over the corridors must be cut. Usually, trees cut within skyline corridors are felled down slope in line with the corridor. If the terrain is level, the corridor trees are felled away from the landing. The trees to be yarded to the corridor from each side often are felled at the same time a corridor is felled. If the residual stand is tight, the landing short, or if turns must be suspended over a stream, the trees are bucked to 20-foot or sawlog lengths at the stump. Directional felling at approximately 45-degree angles to the skyline corridor facilitates lateral yarding and reduces thv chance of damage to the residual stand. The threat of heavy snowfalls, a high probability of hangups, or crew preference may make it desirable, at times, to postpone cutting the trees to either side of the corridor until the system is in place and the trees can be yarded when they are cut.

As soon as the skyline corridors are felled, the tail trees and any intermediate support trees can be rigged with ¼-inch diameter, polypropylene ropes used to pull cables up through the crotches of their support trees when the system is set up. A compound bow equipped with a fishing reel is used to fire a light line attached to an arrow through the crotches. The light line is then tied to the end of a 150-foot piece of polypropylene rope which is pulled into place. Occasional trees without suitable crotches must be climbed and a support block and a strap hung.

To yard timber from along a corridor, the Vermont Cable Yarder and its cable rigging must first be set up, a process which requires two to three crew members. The quickest set-ups involve merely swapping the functions of the haul-in and haul-back lines and threading the skyline up the new corridor, while the longest set-ups involve a complete take-down and set-up of the yarder and all the rigging. A complete set-up is described in the following paragraphs.

The first step of a standard set-up is to drive the yarder into position and to line it up so the rear of the tractor squarely faces the skyline corridor. After making sure the yarder is sitting level, the tower is raised using the double-line pull of the Ramsey electric winch. As the tower approaches vertical, the three tower guylines are pulled out over the front of the tractor and attached to anchors. Continuing its movement toward the vertical, the tower pulls the guylines taut just as it reaches the upright position. The tower is then pinned securely to the tower base.

The working line to be used as the haul-in is threaded from its winch drum, up through its fairlead block in the top of the tower, and is pulled by hand out to the back of the corridor to be yarded. The other working line to be used as the haul-back is threaded through its fairlead and is pulled out to the back of an adjacent corridor where it is threaded through a corner block hung on a tree, then run along the back of the harvest area to a corner block at the back of the corridor to be yarded. The haul-back is threaded through the corner block on the skyline corridor and connected to the end of the haul-in. Once the two lines are connected, the haul-in is winched in, pulling the end of the haul-back down to the landing. If the haul-back is not expected to be long enough to make the loop around the setting, an appropriate number of 200-foot tagline sections are added.

A triangular pulling plate, called the "flying triangle," is connected between the ends of the haul-in and haul-back lines. The skyline is pulled from its storage reel on the front of the tractor, is threaded over its fairlead sheave on top of the tower, then is pulled out and clamped to the flying triangle. Winching in on the haul-back pulls the flying triangle with the attached skyline and haul-in to the back of the skyline corridor. The skyline is then unclamped and the flying triangle is winched back to the landing.

One or two crew members at the back of the skyline corridor tie the rigging rope, which already is threaded through a crotch in the tail tree, to the end of the skyline. Next they pull the skyline up through the crotch and straight back to the base of a tree, where it is anchored with a safety strap and Trewhella clamp. The bearer cables for any needed intermediate supports are threaded in a similar fashion. The supports are hung on the bearer cables, the skyline is placed in the support shoes, and the supports are raised by pulling the free end of the bearer cable. Meanwhile, the yarder operator places the carriage on the slack skyline and detaches the flying triangle from the haul-in and haul-back lines. If a downhill corridor is to be yarded, the haul-back is connected to a snap-link on the back of the carriage, and the haul-in is threaded through the front of the carriage, over a large internal sheave, and out the bottom. The self-releasing choker hook is then clipped onto the end of the haul-in line, preventing it from pulling back through the carriage. If wood is to be yarded uphill, the carriage is turned around, the haul-in is connected to the back and the haul-back is threaded through.

When ready, the slack is pulled out of the skyline, and the double line from the Ramsey winch is clamped on and winched in to raise the skyline just off the ground at the landing. At this time, the trip shoe for the load locking device in the carriage is positioned and attached to the skyline. Once this is done, the skyline is raised to its operating height, and the system is ready.

The system may be rigged using a spar tree for reverse, offset and elevated set-ups when site conditions require it.

Yarding requires a minimum of two crew members, one to operate the yarder and the other to set chokers. If necessary, a third crew member may assist with choker setting. Motorola, two-way radios provide communication between the choker setter and operator.

The yarding normally starts with the wood in the front of the corridor, nearest the landing. Trees yarded laterally to the corridor are yarded butt first when possible, because felling the trees away from the corridor reduces the amount of brush the choker setter must work in. Also, chokers are less likely to slip off butts then tops, and poorly trimmed branches are less likely to catch or damage residual trees.

The choker setter starts the yarding cycle by asking the yarder operator to send the carriage back. With the PTO in high gear, the haul-back is winched in, sending the carriage zipping out into the woods. When downhill yarding, the choker setter allows the carriage to pass by before saying "stop, stop—rollback." This procedure puts slack into the haul-in line, dropping the chokers to the ground and allowing line to be pulled out easily to the side for lateral yarding. When uphill yarding with the carriage turned around, and the chokers on the haul-back, the choker setter calls for the slack on the haul-back before the carriage is coasted to a stop over the hook-up point.

After the chokers and line have been dropped to the ground, the choker setter pulls them out in the direction of the next hitch. The empty 20-foot-long tagline choker set with its self-releasing hook and three chain chokers, are unsnapped from the lateral yarding line and a preset tagline choker set is snapped on. The choker setter steps back into a safe position and calls "in, in" over the radio (double commands are used to reduce the chance of misunderstanding). The lateral yarding line is winched in pulling the hitch (turn) together until the chokered ends are even with each other. At this point, the choker setter calls "stop, stop — slack'er easy" and tension is released from the lateral yarding line. The two chokers on the sliders are quickly transferred to the self-releasing choker hook where the third choker is already attached. This done, the choker setter steps clear and calls "in, in." When the turn is lifted to the carriage and the locking ball has engaged, the choker setter calls "carriage, carriage," and the operator releases the brake on the line that was holding the carriage in place on the skyline and winches the carriage and turn to the landing.

Upon reaching the landing, the carriage passes over the trip shoe hanging from the skyline, and the load is unlocked. Using the winch clutches and brakes, the yarder operator lowers and positions the turn on the deck. When the turn is in the desired place, the lines are quickly slackened, causing the self-releasing choker hook to drop straight down, compressing the hook, and releasing one end of the chokers. The opposite ends of the choker chains remain attached to the self-releaser, pulling them free from deck as the working lines are tensioned and the carriage is returned to the woods.

While the yarder operator is busy winching in and decking a turn, the choker setter presets the tagline chokers on the next hitch. First, the choker attached to the self-releasing hook is set around the end of a log, then the other two chokers on sliders are set on logs somewhat closer to the skyline corridor. When the carriage returns to the woods, the yarding cycle is repeated.

SITES OPERATED

Eight sites were cable yarded during the project. They were done in the following order:

1. Hawkes Lot, Woodstock — training site.
2. Pearsons Lot, Woodstock — training site.
3. Laurance Rockefeller Estate, Woodstock — first study and demonstration site.
4. Cotton Brook Block, Mount Mansfield State Forest, Stowe — second study and demonstration site.
5. Willoughby State Forest, Westmore — third study and demonstration site.
6. Todah Hill Lot, Braintree.
7. Loftus Lot, Sharon.
8. Green Mountain National Forest, Rochester — fourth study and demonstration site.

Hawkes Lot— Initial training was carried out in April on a two-acre thinning of sapling to log-sized, mixed hardwoods situated on a low knoll surrounded by standing water and swampy ground. Because the Vermont Cable Yarder was still being assembled, Woodland Fuels' 16-hp Kubota/Igland System was used. Three corridors averaging 350 feet long were run into the area, starting from a landing in a field and crossing a steep, wet gully before reaching the woods. Deflection was adequate, therefore, no intermediate supports were needed, and the eight-foot-long, prebunched wood and logs could be yarded fully suspended to the landing. Although the terrain was undulating, the general slope of the cables was slightly uphill to the landing.

At the start of training on the site, the weather was blizzard-like and two feet of snow covered the ground. Three weeks later only patches of snow were left but even the high ground was extremely wet and soft. Despite the conditions, 25 cords of wood and 1,400 board feet of logs were yarded and decked without soil disturbance, and virtually no residual stand damage.

Pearsons Lot— During May and into early June, training and testing were continued on a 10-acre site overstocked with pole-sized sugar maple and ash. Water was oozing out all along this north facing slope which dropped steeply down to a stream. A gravel road paralleled to the stream on the opposite side. Ten corridors, ranging from 360 feet to 475 feet long were run from the town road to the back of the harvest area which meant all wood had to cross the stream for decking at roadside. Through the course of operations, there was never a trace of mud in the stream and the banks remained completely undisturbed. Wood was bucked to 20-foot lengths in the woods and much of it was prebunched with the "Radio Horse 9." Only one choker, and one self-releasing hook were used. The heavy, remedial thinning yielded 125 cords of wood and 5,000 board feet of logs. The second half of the yarding at this site was done with the new 34-hp Vermont Cable Yarder.

Laurance Rockefeller Estate, Woodstock — This first study and demonstration site was approximately 7.0 acres of young, pole-sized, 4"-9" diameter at breast height (dbh), mixed northern hardwoods with an initial basal area of approximately 160 square feet. The elevation of the north facing stand was 1,300 feet and a slope of 20 perpent. The stand was marked for a cleaning and weeding cut (Table 11). Five corridors that were layed out ranged from 600 feet to 1,050 feet long. Three of the five were oriented for sidehill yarding while the remaining two were oriented for downhill yarding. The production analysis was conducted on the three sidehill corridors. The landing, located along a logging road which ran adjacent to the stand, had both limited space with a limited visibility for the operator. For corridor one, the landing was 200–300 feet from the operator and for the remaining corridors was 50–60 feet away. The product harvested was mostly log-length firewood with little sawlog material, all of which was bunched.

Chokering problems were encountered because of the small size of the wood being harvested. By the end of operations, the problem was partially resolved by using two chain chokers on the self-releasing hook.

A total of 75 cords of 20-foot-long wood was yarded from this site.

Cotton Brook Block, Mount Mansfield State Forest—This second study and demonstration site was approximately four acres with a mixed northern hardwood-hemlock stand, having an average dbh of 10.9 inches and a total basal area of 138 square feet. The elevation of the stand was approximately 1,200 feet facing southeast and a slope of 50-60 percent. The stand was marked as a selection cut (Table 11). Five corridors, 850 feet long, were oriented for sidehill yarding. The landing was located within 40 feet of the operator on a slight downhill slope. Firewood and sawlog material were cut to length and bunched in the woods. The yarder was able to handle the largest logs. Some bothersome breakages of snap-link sets between haul-back tagline sections were caused by the twisting of the line as logs were raised out of the deep ravine. This did not prove to be a problem on other sites and could be remedied by placing swivels between the tagline sets and better positioning of corner blocks. Other production delays were caused by: marking done prior to the layout of the skyline corridors; inexperienced choppers working on very steep slopes; skyline corridors layed out for easy viewing by onlookers from the road rather than for smooth operation; and failure of the electric motor in the Ramsey winch. Total production was 40 cords of wood and 10,500 board feet of logs.

Willoughby State Forest—This third study and demonstration site was approximately 10 acres of mixed hardwoods having an average dbh of 8.2 inches and a total basal area of 87 square feet. The elevation of the stand was approximately 1,500 feet facing east with a slope of 45 percent and the stand was marked for a commercial thinning. Three corridors were layed out and oriented for uphill yarding. The landings were narrow and located on sloping terrain approximately 50 feet from the yarder. Material consisted of both firewood and sawlog and was not bunched. The three corridors, averaging 500 feet long, were run perpendicular to the road and parallel to each other at 120-foot intervals. On the first two corridors, wood was bucked to 20-foot lengths in the woods before yarding, but on the third corridor, it was left tree-length for yarding, then bucked on the landing. Production with tree-length was considerably higher. Because the yarding was uphill, the trees were directionally felled with ease, therefore, there was little difficulty or damage when laterally yarding the long lengths from between the residual trees. Since one crew member quit in late July, a new felling and choker setting technique was tried with the remaining three-member crew. One man chopped on one side of the skyline while another set chokers on trees he had felled on the other side, and the third man operated the yarder. The two men in the woods alternated chopping and choker setting on their respective sides of the skyline, working their way from the bottom of the slope to the top. By this time, a three-choker system had evolved using the single self-releaser. This method worked so well that a second self-releasing choker hook and special choker chains were ordered from Scotland, enabling chokers to be preset. A brief trial of sliding cable chokers was made and the following problems were encountered: they could not be adjusted as chain chokers so the load could not be pulled up close to the carriage; they could not self-release on the landing; they tended to tangle because they were old and somewhat kinked.

Production from this steep demonstration site was 38 cords of wood and 384 board feet of logs.

Todah Hill Lot—Located on approximately eight acres of Todah Hill Foundation woodland in Braintree, near Randolph, this site was operated primarily for testing production techniques. The ground was broken and rocky and the slopes ranged from slightly uphill, to level, to steep downhill. Wood was bucked either in 20-foot lengths in the woods or yarded tree-length. A moderate to heavy removal of the poorest quality trees in the pole-sized stand on mixed hardwoods yielded 90 cords of firewood.

Loftus Lot—During the month of October, a selective thinning was carried out on 12 acres of overstocked sugarbush in Sharon. Eight corridors, ranging from 400 feet to 850 feet long, were run from two landings on the edge of a field. From the first landing, four corridors ran up a steep bank with ledge outcroppings, over a steep sided gully, then over gently sloping ground to the back of the sugarbush, requiring one or two intermediate supports on each corridor. The diameter of the trees in the stand accessed from the first landing ranged from one to four feet. From the second landing, thinnings were yarded out of a young sugarbush on a steep sidehill; here tree diameters ranged from two to twelve inches. The wood was bucked to 20-foot lengths in the woods to minimize stand damage. However, logs larger than 30" in diameter were cut 8-10 feet long. Wood yarded to the first landing was prebunched with the "Radio Horse 9," but the second self-releasing hook and special choker chains had arrived from

Scotland by the time the move was made to the second landing. Self-releasing, tagline choker sets were put into service so that turns could be preset, significantly increasing production. After the tagline choker method was adopted, bunching with "Radio Horse 9" was no longer used. In all, 108 cords of wood were yarded to the two landings and the sugarbush was left in the park-like condition.

Green Mountain National Forest, Rochester — This site was approximately 25 acres of mixed northern hardwood which was originally cut in 1972 and, as a result, was very brushy with reproduction. The average dbh for material five inches and greater was nine inches with a basal area of 50 square feet. The elevation of the stand was approximately 1,300 feet facing south with a 25 percent slope. The stand was marked for an overstory removal with both sawlogs and firewood material. All five corridors were oriented for downhill yarding and one was studied. The landing, consisting of one large area for firewood and a separate area for sawlogs, was divided into two areas by a logging road, which ran perpendicular to the corridors. Sawlogs were landed on the road embankment and the tree-length firewood was decked on a level area. Yarding the firewood tree-length increased the average turn size and made decking at roadside easier. Approximately four of the 25 acres were harvested, yielding 42 cords of wood and 7,800 board feet of logs.

SUMMARY DESCRIPTION OF THE VERMONT CABLE YARDER

This small, double-drum yarder was developed by Woodland Fuels in cooperation with the Vermont Department of Forests, Parks and Recreation and the U.S. Forest Service to yard timber over adverse terrain with minimal site disturbance.

The Igland, double-drum winch unit is mounted on the rear of a Kubota, 34-hp, four-wheel drive, diesel tractor, and powered from the PTO. A tower unit pins into mounting brackets and can be easily folded down for transport.

Maximum yarding distance is 900 feet with 1,000 feet of 5/16-inch cable on each winch drum plus 1,400 feet of tagline added to the haul-back. The yarder may be rigged as a highlead, non-interlocking, running skyline, or a gravity shotgun, but is used almost exclusively as a standing skyline system. The skyline is stored on a front mounted reel.

The tractor's two-speed PTO allows the skyline carriage to be returned to the woods at speeds up to 850 feet per minute in high gear. Shifting to low gear allows a maximum speed of 400 feet per minute.

Both the tractor and winch are very durable. Because the tractor and winch remain stationary at the roadside, there is minimal chance for damage to the equipment, as well as an increase in fuel economy of several times over that of conventional ground skidding.

Log decks can be built eight to ten feet high at the roadside with the lift provided by the tower or to heights of 20 feet or more when the skyline is supported by a spar tree. Use of a self-releasing choker system allows logs to be pulled onto a roadside deck and remotely unhooked by the operator at the winch controls, making the decking operation safe and efficient.

The Vermont Cable Yarder has many advantages when compared with conventional ground skidding methods. A few of the advantages are:

Three dimensional versus two dimensional yarding. For example, log-length turns can be lifted around tight corners and into narrow skyline corridors with no residual stand damage, whereas ground-skidded turns, confined to the horizontal plane, will bind and damage the residual stand.

The skyline provides a smooth, straight tract for the carriage and turn of logs to travel compared to ground skidding, which often must use an indirect route over rough terrain to reach the landing.

The power of the yarder is effectively used because the turns are lifted free of ground obstructions and nothing is lost to moving the weight of the machine or to wheel slippage.

The low yarder power inherently reduces stand damage and equipment breakage.

Very steep terrain may be yarded, since there is no roll-over danger and little soil disturbance.

Yarding is not hampered by poor ground conditions such as mud or snow.

Timber stays clean, and can be decked neatly and compactly at roadside.

There are no systems manufactured in North America that have met the harvesting needs of the eastern United States and Canada. European systems most closely match these needs, but they tend to be both too expensive and fragile for the North American logger. Using winches from Norway, skyline carriage and rigging components from Scotland, a Japanese tractor, and a tower designed by Woodland Fuels and fabricated in Vermont, the Vermont Cable Yarder offers a combination of low cost, versatility, durability and productivity, given the current state-of-the-art. This yarder should provide a suitable means for low impact thinning and harvesting, until a more suitable yarder comes on the market.

CHAPTER III: TEST RESULTS OF THE VERMONT CABLE YARDER

by Neil Huyler

The following chapter reports the study results of a cost and productivity analysis conducted for the Vermont Cable Yarding System. The results are based on detailed time studies of the operation on four sites and overall operating time and cost records provided by the contractor, Gerry Hawkes.

The research objective of the study were twofold: (1) to evaluate the production capabilities and cost of production under varied stand and site conditions; and (2) to evaluate residual stand damage.

STUDY METHODS

Field Data Collection

Time studies were conducted on each of the four sites for a one- to two-week period.

Laurance Rockefeller Estate

Cotton Brook Block, Mount Mansfield State Forest

Willoughby State Forest

Green Mountain National Forest, Rochester

In addition to the detailed time study, daily shift records of the hours worked and volume harvested were kept by the contractor. All expenses incurred during the test phase, such as gas, oil, wages and maintenance repair, were recorded. These data were used as the basis for the operating cost evaluations.

Yarding Cycle Time

Yarding cycle time is the amount of time it takes the carriage to go from landing area to the woods and return to the landing and unhook the payload. The following elements of the yarding cycle times were identified and measured using the continuous timing method.

Elements Of Yarding Cycle

Out Haul Empty — Begins when the operator is ready to move carriage from the landing out to the choker setter and ends when the choker setter touches the chokers.

Lateral Out — Begins at the end of the out haul empty element and ends when the choker setter is ready to *hook* a turn. (Choker setter's forward motion has stopped and he is ready to start setting chokers.)

Hookup — Begins at the end of *lateral out* element and ends when the choker setter has completed hooking chokers and signals to begin yarding.

Lateral In — Begins at the end of the *hookup* element and ends with the turn is pulled up to the *carriage and carriage begins to move* up the corridor.

Reset — An element which may occur when a line becomes hung up and one or more logs have to be rechokered. It begins when the choker setter signals for the turn to stop and ends when the turn begins to move up the corridor again.

In Haul — Begins at the end of the *lateral in* element or *reset* element and ends when the turn has reached the position on the deck where it can be directly unhooked at the landing.

Unhooked — Begins at the end of the *in haul* element when the carriage passes over the trip block and ends when the chokers have returned to the carriage.

Delays

The delays were separated into two categories: (1) operating delays and (2) experimental delays. Operating delays were those considered to be part of normal operation, experimental delays were those due to experiments being conducted on the system.

Yarding Cycle Variables

The yarding cycle variables used in production determination were recorded as follows:

Skyline Slope Distance — On each skyline corridor, the ground slope distance was measured and marked every 50 feet down the corridor. The slope distance was recorded for each turn.

Lateral Distance — The lateral yarding distance was measured either by pacing the distance or by visually estimating to the nearest 10 feet.

Volume — Each piece was measured in the corridor and marked with an identification number and was recorded by turn number. The large and small end diameters (dib) and length were measured; volume was calculated by use of the formula for small round products:

$$\text{Vol.} = 0.2618\,L\,\frac{(D^2 + d^2 - dD)}{144}$$

Vol. = volume in cubic feet

L = length of piece in feet

D = large end diameter in inches

d = small end diameter in inches

Carriage Height — The height of the carriage above ground at the position of lateral yarding was estimated by eye to the nearest five feet for each turn.

Number of Pieces Per Turn — The number per cycle was recorded. In addition, the number of intermediate supports was recorded on each corridor.

Corridor or Site Changes

Specific elements were identified and were originally intended to be measured; however, because of insufficient time and manpower, the specific elements were not timed. The times involved in changing corridors on each site were recorded by wristwatch to obtain an overall corridor change time. This was also the case when moving to a new site or location. These periods were considered non-production time in the operation.

Residual Stand Damage

Residual stand damage estimates were made to determine the type of damage and the number of trees damaged per acre as a result of using the cable yarding system.

The field procedure was to use the point sampling technique for estimating the basal area and number of trees per acre. The number of plots taken on each site varied depending on the size of area cut. For example, at least 10 plots were sampled for sites less than 10 acres, for 11 to 40 acre sites, at least one plot per acre was sampled.

The damage was classified as to either felling damage or yarding damage. The types were separated into four categories: (1) bark abraded; (2) bark skinned; (3) root damaged, and (4) tree destroyed. The average width and length of abraded and skinned wounds were recorded.

Bunching

Bunching was not considered in the orginal concept of the cable yarding system. However, a radio-controlled prebunching winch was used on part of the Rockefeller, Cotton Brook and Willoughby sites. These times were not considered in the analysis.

DATA ANALYSIS

The following section presents three types of data that were obtained during the project: (1) system time distribution — taken during one- to two-week production studies with detailed continuous timing; (2) volume estimates of pieces yarded during the detailed time study; (3) corridor change time estimated from operator's records and also site change time requirement taken from operator records and time study records. A summary of the yarding cycle time elements and production variables are presented in Tables 1-4 for each of the test sites. Table 5 presents a combined summary of all four sites.

Rockefeller — Site 1

The total average run time, including operation delay, on the Rockefeller Site was 10.18 minutes with an average skyline slope distance of 542.8 feet (Table 1). The productive turn time, no delays, was 6.88 minutes per turn. The operational delay time average 3.30 minutes per turn. (See delay analysis section.) The machine utilization rate for this site was 68 percent. This does not include any set-up time or site change time. The total scheduled hours on this site were 41 hours. The productive time was 17.8 hours resulting in a utilization rate of 43 percent. This includes 6.5 hours for set-up time of the system.

The volume produced per turn averaged 10.28 cubic feet and the average number of stems per turn was 4 stems. Based on these production standards, the system produced slightly more than 7½ cords per 10-hour work shift. The potential production for the system, excluding all delays, was 89.65 cubic fee per productive hour or about 11¼ cords per 10-hour work shift.

Cotton Brook — Site 2

The total turn time on the Cotton Brook Site was 8.42 minutes, with an average skyline slope distance of 424.01 feet (Table 2). The productive turn time, excluding delays, was 5.81 minutes per turn while the operational delay time averaged 2.88 minutes per turn. The machine utilization rate was 69 percent of this site. No corridor change or site change time was recorded.

The total scheduled hours of work was 40 hours during the study period. The productive machine time during the study period was 19.47 hours, resulting in a system utilization rate of 46 percent. This includes set-up time only for the system.

The volume produced per turn was 13.76 cubic feet and the average number of stems was 1.5 per turn. Based on this production information, it was estimated that the system could produce about 12¼ cords per 10-hour shift. The potential production, no delays, was 142.10 cubic feet per production hour or about 17¾ cords per 10-hour work shift.

Willoughby — Site 3

The total turn time on the Willoughby Site was 10.54 minutes with an average skyline slope distance of 296.35 feet. The productive turn time, excluding delays, was 7.07 minutes per turn. The operational delay time average 3.91 minutes per turn. The machine utilization rate was 67 percent. This does not consider set-up, corridor changes or site change times (Table 3).

The total scheduled work time was 38.5 hours during the study period. The productive machine time during the study period was 13.67 hours, resulting in a system utilization rate of 36 percent, which included set-up and corridor change time for the system.

The volume produced per turn was 17.28 cubic feet and the average number of stems per turn was 1.83. Estimated production of the system on this site was about 12¼ cords per 10-hour work shift. The potential production, no delay included, is 146.65 cubic feet per hour or about 18⅓ cords per 10-hour work shift.

Rochester — Site 4

The total turn time on the Rochester Site was 13.06 minutes with an average skyline slope distance of 366.42 feet. The productive turn time, excluding delay time, was 8.68 minutes per turn while the operational delay time at the site was 4.75 minutes per turn. The machine utilization rate was 66 percent, not including time for set-up, corridor or site change time (Table 4).

The total scheduled work hours during the study period was 32. The production machine time was 17.22 hours, resulting in a system utilization rate of 54 percent. This does not include set-up time only on this site.

The volume produced per turn was 22.45 cubic feet and the number of stems per turn was 2.2. Estimated production for a 10-hour work shift day is 12.9 cords and the potential production for a 10-hour work shift is 155.18 cubic feet, or about 19.4 cords per day.

Combined Sites

Table 5 is a summary of the yarding cycle time elements and production variables for all four sites combined, representing 568 complete cycle observations. The main total turn time was 10.25 minutes with an average slope distance of 417.68 feet. Productive turn time, excluding delays, was 6.93 minutes per turn. Mean operational delay time for all four sites combined was 2.57 minutes per turn and the machine utilization rate was 68 percent over all four sites (Table 5).

The total scheduled work hours during the four study periods were 153.5. Productive machine hours totaled 68.26 hours, resulting in a system utilization rate of 44 percent. This includes set-up, corridor change but not site change time. There was no site change time recorded during the time study period.

Volume produced over the four sites averaged 15.3 cubic feet per turn and the number of stems per turn was 2.4. The estimated production based on a 10-hour work shift is 11.2 cords per day. The potential production, no delays included, is 132.47 cubic feet per hour, or about 16.56 cords per 10-hour day.

Delay Analysis

A summary of the percent delay time is presented in Table 6. The delays were broken down into five primary categories to further identify the causes of delay during the study period. The following primary delay categories were recorded:

— Mechanical Breakdowns — Breakdowns that were associated with the tractor, carriage, line (cable), breaks, etc.

— Set-Up Delays — Any delay that occurred in setting up of the system, such as moving equipment or obstructions, rigging lines, etc.

— Operational Delays — This category represents delays associated with the main function of the system, such as working at landings, chokers caught, wait for choker setter, etc.

— Servicing and Maintenance — These were minor delays associated with maintaining the system during regular operating time.

— Non-Production — These were delays associated with research or other non-production elements.

The total delay time during the time period was 2259.5 minutes or approximately 42.7 hours. This represents about 33 percent of the total production time; therefore, the overall utilization rate or system's efficiency is about 67 percent.[1]

The major delay time was operational delay accounting for 56.7 percent of the total delay time. Set-up delay time was the next most frequent delay accounting for 33.4 percent of the total delay time. Mechanical was the third most occurring delay followed by servicing and maintenance and non-production delay accounting for 7.9, .7, and 13 percent, respectively (Table 6).

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[1] More detailed delays data are available from the author.

The specific type of delay that had a high rate of occurrence, 61, and was among the highest percentage delay, 9.64 percent, of the total time, was chokers being caught up or wrapped around the skyline. Also significant was choker release failure, which accounted for 4.59 percent of the total delay time. Other common delay factors were landing related, such as waiting for operator to return to the tractor, loading log truck, and operator working on log pile. See Table 6 for a complete description and number of occurrences of the specific delay factors.

Corridor and Site Change

An important attribute of a small cable yarder system is its mobility, that is, how quickly the system can be disassembled, "taken down," and then reassembled "set-up." Depending on how the harvesting site is laid out, the take-down and set-up of the system may be necessary for each corridor change and when the harvesting site is changed. Records were kept by the contractor on corridor changes and site changes by clock hours for each of the four study sites and two additional sites. Table 7 is a summary of the clock hours required for set-up, take-down and corridor change times.

For the study period, corridor change time required an average of 7.1 hours/corridor or 14.3 percent of the total on-site productive time. The set-up time after a site change required an average 14.6 hours, 8.6 percent of the productive time. The take-down time required an average of 2.9 hours, about 1.7 percent of the total productive time. Therefore, the average on-site time to set-up, change corridors, and take-down required about 24.6 percent of the total on-site time.

Residual Stand Damage

Damage to the residual stand will occur with any system of logging. It's important to be aware of this and use a system that best fits the needs and good logging practice to minimize the damage.

The residual stand damage was examined by point sampling techniques and is recorded for each site as shown in Table 8. Damage category number 1 is bark abrasion—tree bark rubbed but bark intact—which is of questionable significance. In view of this, it was eliminated in this analysis.

In general, the damage was greatest on sites where the corridors were oriented across the slope (Sites 2 and 3). This would be expected as the stems coming in along the corridors had a tendency to slide to the downhill side, thereby causing damage to the trees along the boundary of the corridor.

COST OF PRODUCTION

The total cost of wood at the landing for the four sites combined is $37.45 per cord or $41.94 per scheduled hour. This cost does not include stumpage, pre-harvest inventory or surveying, or marking cost. If the Rockefeller Site (Site 1) is excluded from the analysis, the total cost per cord becomes $33.60. The $3.85 per cord difference is due largely to the increase in average production rate when Site 1 is excluded. Table 10 shows the breakdown of the fixed, variable or operating and labor costs per scheduled hour and per cord basis.

SUMMARY

The preliminary results of the study indicate that the system's *potential production* is at a level that makes it an economically sound system for thinning northern hardwood stands. But a few system design changes and overall system operation change would be required to increase the efficiency or machine utilization rate.

As mentioned earlier in the text, the system's overall utilization rate was about 44 percent. This result of a 32 percent delay time in normal operation and about a 24 percent time requirement in corridor change and site change time. These are two obvious areas where changes or modifications are necessary to increase the system's overall efficiency. The following are the important problem areas:

Yarder. The bearing between the tractor and the winch had excessive wear accounting for approximately 5 percent of the system's downtime. A substantial amount of time was required to raise and lower the skyline. This was done by an electric winch which was very slow and was operated at or near maximum capacity, causing it to overheat. Perhaps a hydraulic motor driven winch could increase the speed and cause fewer malfunctions.

Operational. As with many cable yarding systems, the landing is always a potential problem area. This was a major cause of delay time. For example, choker caught in log pile accounted for 9 percent of the delay time. Operator working on log pile accounted for 7 percent of the delay time. Waiting for logging truck was another factor causing interruption in the system's efficiency. Methods or techniques to keep the log deck from becoming more than 10 to 15 feet high would increase the system's efficiency.

Corridor and Site Change. Corridor change time accounted for about 24 percent of the total on-site time. Since a detailed time analysis was not conducted on this segment of operation, it is difficult to precisely identify the reason for the excessive time required. However, from the gross time records and field observation, there were several factors where considerable time was required in corridor change-over. Among them were tail tree changes, intermediate support installations, adding and deleting taglines to the haul back, repairing tagline connections, stringing operating lines without a strawline, winding in and raising the skyline on the reel by hand. To keep the cost of the yarder low, many time-saving conveniences were sacrificed. These sacrifices were most noticeable when making corridor changes.

The concept of a cable yarding system capable of handling small roundwood products and commercial-size timber in the Northeast has merit. Further investigation of the use of the system for thinning or other intermediate cuttings is necessary before firm conclusions or recommendations can be made as to the system's applicability and economics.

Table 1. Summary of Yarding Cycle Time Elements and Production Variables — Rockefeller (Site 3)

Element	Number of Observations	Average Time/Turn	Maximum Time	Percent
		Minutes		
Out Haul Time	157	1.10	3.26	15.2
Wait for Choker Setter	143	.40	6.72	5.5
Lateral Out	118	1.26	5.64	17.4
Hook-Up	126	.98	5.07	13.5
Lateral In	137	.67	4.62	9.2
Reset	157	.51	8.00	7.0
In Haul	149	1.68	5.73	23.2
Unhook	150	.65	5.75	9.0
Total Productive Time[a]	150	6.88	20.17	100.0
Delay Time	157	3.30	86.93	
Total Turn Time	150	10.18	94.42	

Production Variables	Minimum	Maximum	Average
Skyline Slope Distance (ft)	250.00	900.0	542.85
Lateral Yarding Distance (ft)	0	60.0	24.42
Number of Stems Per Turn	1.00	13.0	4.00
Volume Per Turn (ft^3)	1.58	41.1	10.28

[a] Total productive time is the mean time based on 150 complete cycle times; therefore, the sum of individual element times will not always equal total productive time.

Table 2. Summary of Yarding Cycle Time Elements and Production Variables — Cotton Brook (Site 4)

Element	Number of Observations	Average Time/Turn	Maximum Time	Percent
		Minutes	Minutes	
Out Haul Time	206	0.87	2.08	14.9
Wait for Choker Setter	202	0.60	5.20	10.3
Lateral Out	178	0.52	2.50	8.9
Hook-Up	186	1.40	5.18	24.0
Lateral In	201	0.50	2.50	8.5
Reset	206	0.27	6.10	4.6
In Haul	205	1.15	5.11	19.7
Unhook	199	0.53	2.22	9.1
Total Productive Time[a]	192	5.81	14.98	100.0
Delay Time	206	2.88	80.80	
Total Turn Time	192	8.42	83.14	

Production Variables	Minimum	Maximum	Average
Skyline Slope Distance (ft)	25.00	860.0	424.01
Lateral Yarding Distance (ft)	0	60.0	19.02
Number of Stems Per Turn	1.00	5.0	1.53
Volume Per Turn (ft^3)	2.61	49.25	13.76

[a] Total productive time is the mean time based on 192 complete cycle times; therefore, the sum of individual element times will not always equal total productive time.

Table 3. Summary of Yarding Cycle Time Elements and Production Variables — Willoughby (Site 5)

Element	Number of Observations	Average Time/Turn	Maximum Time	Percent
		Minutes	Minutes	
Out Haul Time	122	1.06	3.88	13.9
Wait for Choker Setter	118	.43	2.11	5.6
Lateral Out	94	.85	3.91	11.1
Hook-Up	114	1.89	6.00	24.7
Lateral In	116	.77	2.81	10.1
Reset	122	.79	6.78	10.3
In Haul	116	1.04	2.78	13.6
Unhook	114	.82	3.80	10.7
Total Productive Time[a]	108	7.07	17.44	100.0
Delay Time	122	3.91	39.69	
Total Turn Time	108	10.54	54.26	

Production Variables	Minimum	Maximum	Average
Skyline Slope Distance (ft)	0	550.00	296.30
Lateral Yarding Distance (ft)	0	65.00	21.80
Number of Stems Per Turn	1.00	4.00	1.83
Volume Per Turn (ft^3)	3.08	44.61	17.28

[a] Total productive time is the mean time based on 108 complete cycle times; therefore, the sum of individual element times will not always equal total productive time.

Table 4. Summary of Yarding Cycle Time Elements and Production Variables — Rochester (Site 8)

Element	Number of Observations	Average Time/Turn	Maximum Time	Percent
		Minutes		
Out Haul Time	120	.88	4.05	10.0
Wait for Choker Setter	115	.60	3.38	6.9
Lateral Out	106	1.73	5.63	19.8
Hook-Up	116	1.32	7.52	15.2
Lateral In	117	1.03	4.62	11.8
Reset	120	1.44	10.94	16.5
In Haul	119	1.13	6.38	12.9
Unhook	119	.60	2.55	6.9
Total Productive Time[a]	118	8.68	39.73	100.0
Delay Time	120	4.75	80.04	
Total Turn Time	118	13.06	93.16	

Production Variables	Minimum	Maximum	Average
Skyline Slope Distance (ft)	0	700.00	366.40
Lateral Yarding Distance (ft)	0	80.00	23.40
Number of Stems Per Turn	1.00	5.00	2.16
Volume Per Turn (ft³)	1.38	94.43	22.45

[a] Total productive time is the mean time based on 118 complete cycle times; therefore, the sum of individual element times will not always equal total productive time.

Table 5. Summary of Yarding Cycle Time Elements and Production Variables — Combined Sites (Sites 3, 4, 5, 8)

Element	Number of Observations	Average Time/Turn	Maximum Time	Percent
		Minutes		
Out Haul Time	605	.97	4.05	13.6
Wait for Choker Setter	578	.51	6.72	7.1
Lateral Out	496	1.02	5.64	14.3
Hook-Up	542	1.39	7.52	19.4
Lateral In	571	.70	4.62	9.8
Reset	605	.67	10.94	9.4
In Haul	589	1.26	6.38	17.6
Unhook	582	.63	5.75	8.8
Total Productive Time[a]	568	6.93	39.73	100.0
Delay Time	605	3.57	86.93	
Total Turn Time	568	10.25	94.42	

Production Variables	Minimum	Maximum	Average
Skyline Slope Distance (ft)	0	900.00	417.70
Lateral Yarding Distance (ft)	0	80.00	21.90
Number of Stems Per Turn	1.00	13.00	2.36
Volume Per Turn (ft³)	1.38	94.43	15.30

[a] Total productive time is the mean time based on 568 complete cycle times; therefore, the sum of individual element times will not always equal total productive time.

Table 6. Summary of Delay Analysis — All Sites Combined

Delay Category	Description	Occurrences	% of Total
Mechanical 7.9%	Broken bearing on tractor	1	3.37
	Working line broken	2	2.09
	Winch repair	2	1.77
	Carriage caught-up	1	0.26
	Adjusting tractor clutch	2	0.24
	Tractor stalled	4	0.14
	Adjusting tractor throttle	1	0.03
Set-Up 33.4%	Loading logging truck	5	9.79
	Tail tree change	2	8.82
	Pulley/cable snag	2	3.11
	Clearing corridor obstructions	25	3.04
	Working line broken	1	2.00
	Rigging another guyline	1	1.47
	Moving carriage trip	2	1.10
	Remove or add tag line	4	0.67
	Operator working on pile	3	0.50
	Block adjustments	1	0.50
	Pulling leaner down	2	0.50
	Wait for choker setter	1	0.40
	Adjusting intermediate support	1	0.37
	Adjusting choker chains	3	0.37
	Adding additional blocks	2	0.33
	Raising working lines	2	0.13
	Clearing view and obstructions	1	0.13
	Skyline tension work	1	0.13
Operational 56.7%	Choker caught-up	61	9.64
	Operator working on pile	68	7.09
	Cable spool on tractor	14	4.82
	Choker release failure	49	4.59
	Wait for operator	85	4.48
	Weather	3	3.51
	Carriage caught-up	3	3.34
	Load caught in woods	32	2.95
	Carriage fell off skyline	2	2.44
	Cutting stem	23	2.38
	Carriage release adjustment	6	2.04
	Clearing brush	11	1.47
	Chokers caught in log pile	10	0.79
	Manually dropping chokers	6	0.74
	Break time	5	0.68
	Communications delay	7	0.68
	Working line snagged	5	0.62
	Skyline tension work	3	0.62
	Limbing stem	9	0.57
	Untangle lines	4	0.45
	Work on working lines	4	0.40
	Crew in way of working lines	9	0.34
	Wait for feller	2	0.28
	Adjusting choker chains	5	0.28
	Repositioning carriage	4	0.28

Delay Category	Description	Occurrences	% of Total
Operational 56.7% (Continued)	Wait for choker setter	4	0.23
	Bunching a load	1	0.23
	Switching operators	3	0.17
	Felling a tree	2	0.11
	Wait for supervisor	1	0.06
	Wait for radio winch	1	0.06
	Raising working lines	1	0.06
	Lowering skyline	1	0.06
	Adjusting radio or earpiece	1	0.06
Servicing 0.7%	Winch repair	1	0.40
	Greasing cables	1	0.18
	Checking cable wear	1	0.12
Non-Production 1.3%	Wait for researchers	13	0.60
	Camera or demonstration session	5	0.45
	Vehicle passing under cables	6	0.25

Table 7. Summary of Set-Up, Take Down, and Corridor Change Time by Site in Clock Hours

			Corridor Change	
Site	Set-Up	Take Down	Number of Corridors	Total Time
	Hours			Hours
Rockefeller*	9.5	5.2	4	22.2
Cotton Brook*	11.2	Not Recorded	1	5.5
Willougby*	11.0	Not Recorded	2	21.0
Randolph	15.5	2.5	4	33.0
Sharon	22.0	1.0	6	39.5
Rochester*	18.5	Not Recorded	Not Recorded	
Average	14.6	2.9	17	24.2 7.1/corridor
Percent of Total Productive Time	8.6	1.7	14.3	

*Study sites.

Table 8. Residual Stand Damage by Category for Each Study Site

Site Identification	Damage Category[a] 1[b]	2	3	4	Total Number of Trees Damaged Per Acre	Total Number of Trees Per Acre	Percent Damaged
	Number of Trees Per Acres						
Rockefeller, Site 3	(13.7)	8.9	15.7	2.8	27.4	119.9	22.8
Cotton Brook, Site 4	(1.9)	22.9	5.8	.9	29.6	115.7	25.6
Willoughby, Site 5	—	29.7	5.1	—	34.8	166.4	20.9
Rochester, Site 8	—	33.5	7.3	2.3	43.1	1005.8	4.3

[a] Damage Category Identification

Class 1 — Bark abrasion — bark rubbed but intact.
Class 2 — Bark skinned — bark rubbed off.
Class 3 — Root damage — exposed, torn or broken.
Class 4 — Tree bent over or broken off — tree destroyed.

[b] Not considered as a significant damage, therefore, excluded from the total trees damaged and percent damaged.

Table 9. Machine Purchase Price and Criteria for Cost Analysis

Machine Components	Purchase Price	Economic Life	Number of Scheduled hr per yr	Machine Utilization (a)
	Dollars	Years		Percent
Tractor	$10,800	6	1,800	68
Winch	5,700	6		
Cables	4,800	3		
Tower	1,600	6		
Skyline Reel	1,200	6		
Rigging	2,000	6		
Carriage	1,900	3		
Intermediate Supports	900	6		
FM Radios	2,800	6		
Winch Mounting	950	6		
Rigging Hardware & Support Tools	2,200	6		
Sub-Total	$34,850			
Research and Design	10,150			
Total	$45,000			
Additional Cable (b)	4,800			
Additional Carriage (c)	1,900			
Total System Cost	$51,700			

(a) Does not include setting up or taking down the system; when this is included, the MU becomes 43 percent.
(b)-(c) Cost for cable and carriage replacement after the three year estimated life.

Table 10. Cable Yarder Cost Per Cord[a] for All Sites Combined

Machine Cost	Per Cord Basis	Per Hour Basis	Percent of Total
	Dollars		
Fixed Cost[b]	6.27	7.03	16.8
Variable Cost[c]	1.05	1.17	2.8
Labor Cost			
Wages	20.09	22.50	53.6
3 Persons @ $5.00/hr.			
1 Foreman @ $7.50/hr.			
Fringe Benefits	10.04	11.25	26.8
Total Cost	37.45	41.94	100.0

[a] Based on a production rate of 1.12 cords per scheduled hour for all sites.

[b] Fixed cost includes interest at 10 percent per year straight-line depreciation schedule, insurance @ $.75/100, and tax @ .75 percent of purchase price.

[c] Variable cost includes fuel, lubricants, and maintenance and repair costs.

[d] Excluding Site 1 this becomes $33.60/cord due to increased production to 1.22 cords per scheduled hour.

Table 11. Summary of Study Variables for the Four (4) Study Sites

Study Variables	Site 3	Site 4	Site 5	Site 8	Combined Sites
Type of Cut	Weeding & Cleaning	Selective Cut	Thinning	Overstory Removal	——
Up or Downhill Yarding	Sidehill Yarding	Sidehill Yarding	Uphill	Downhill	——
Average Volume/Turn (ft^3)	10.28	13.76	17.28	22.45	15.30
Average Number Stems/Turn	4.00	1.53	1.83	2.16	2.36
Average Slope Distance (ft)	542.8	424.0	296.3	366.4	417.7
Total Turn Time (Minutes)	10.18	8.42	10.54	13.06	10.25
Machine Utilization Rate (Percent)[a]	68.00	69.00	67.00	66.00	68.00
Systems Utilization Rate (Percent)[b]	43.00	46.00	36.00	54.00	44.00

[a] Includes delay time.

[b] Includes delay time and time for set up and take down of the system.

Figure 1. Cost Per Cord by Site Harvested

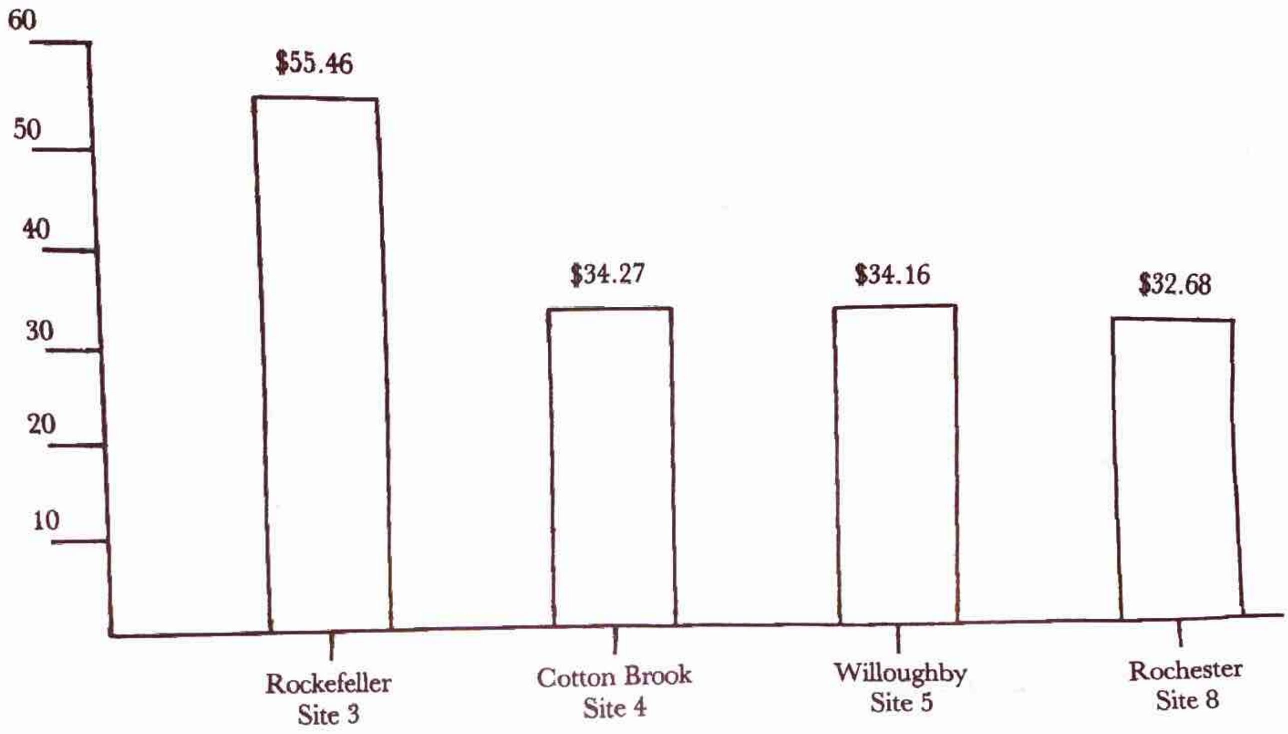


Figure 4. Percent Distribution of Owning and Operating Cost

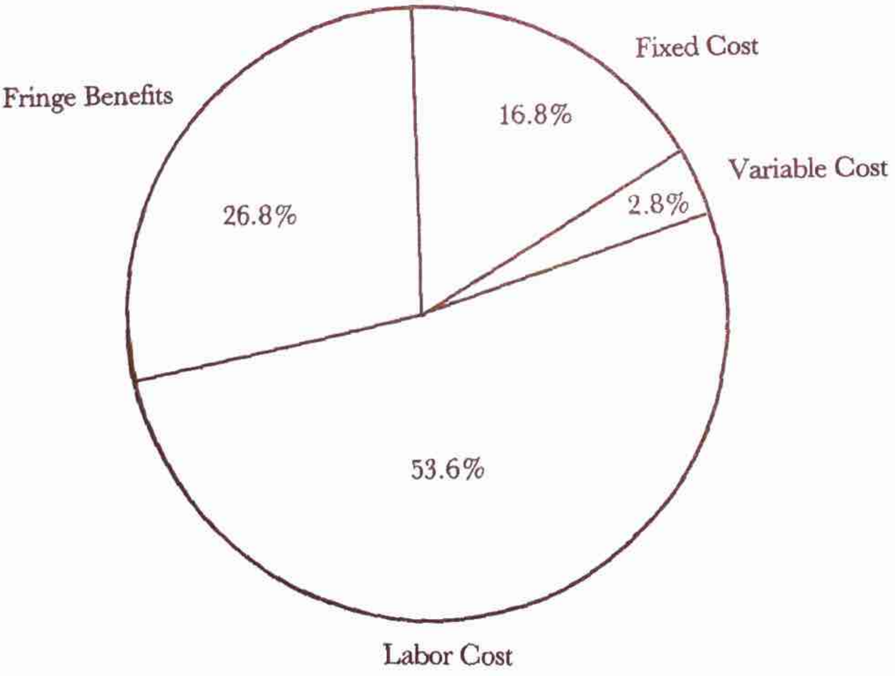


Figure 2. Percent Distribution of Productive Time[1] *(All Sites)*

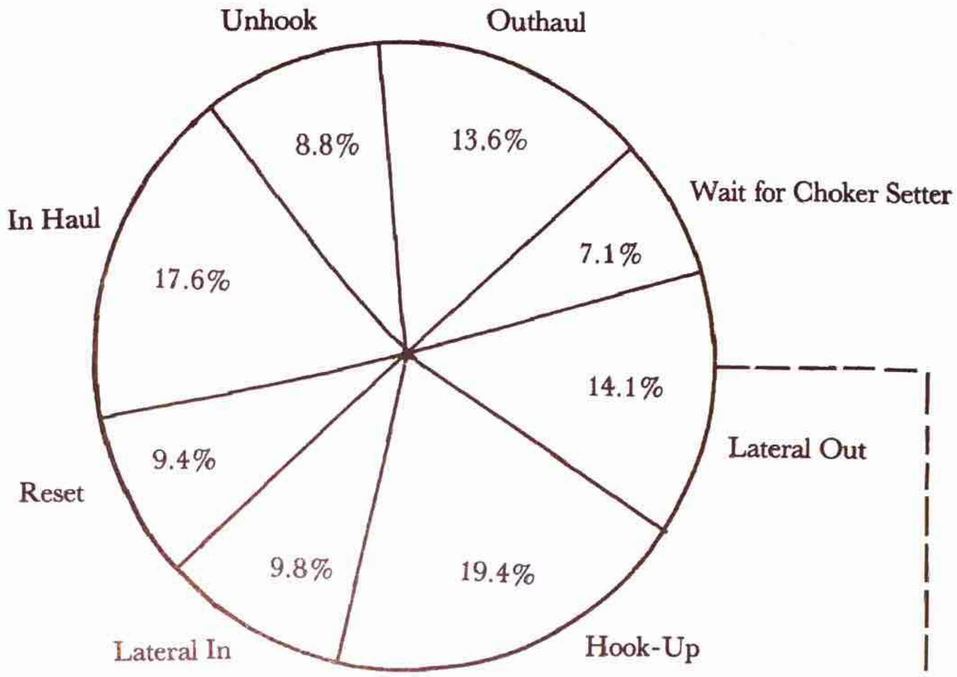
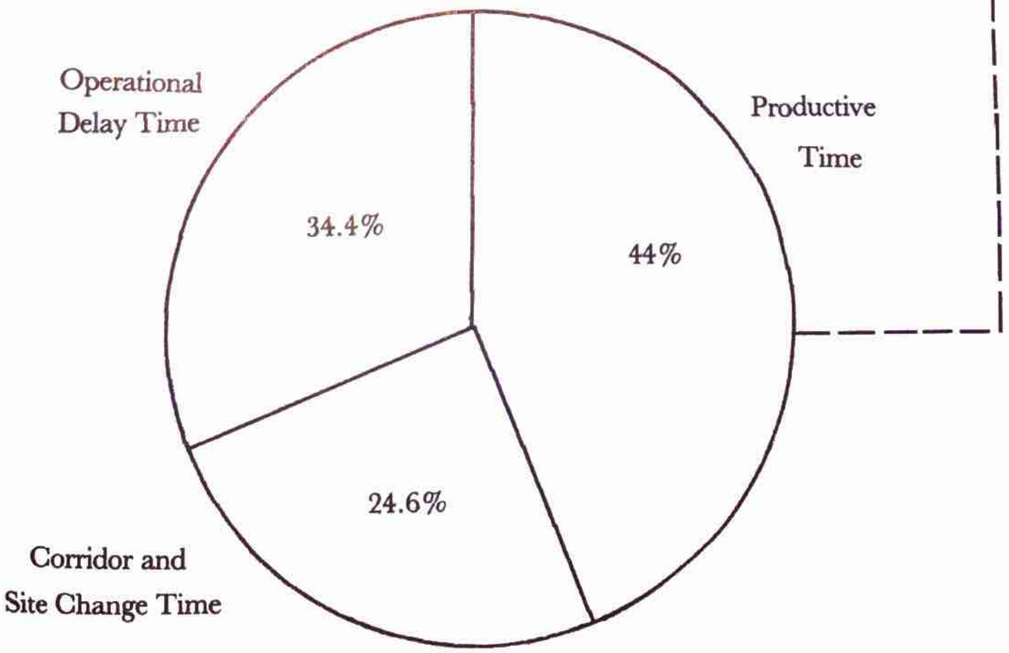


Figure 3. Percent Distribution of Total On-Site Time (All Sites)



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[1] No Delay

CHAPTER IV: VERMONT CABLE YARDING DEMONSTRATIONS

by Jack Dwyer

Four public demonstrations of the Vermont Cable Yarder were conducted before a registered attendance of 989. In addition to these public demonstrations, separate tours were conducted for school, industry, forestry, conservation and political groups.

The demonstration sites were in four locations around the state. Each of these sites differed in topography, timber type and size, cutting prescription and method of harvest (sidehill, downhill and uphill removal of timber).

The demonstrations were conducted to show woodland owners, loggers, wood-using industry, truckers, foresters and the general public a harvesting system new to the Northeast, and to elicit their views of this technique.

The attendance at these demonstrations was excellent in terms of the numbers of attendees, the cross-section of people that saw the system and their comments regarding its acceptance, feasibility and operation.

The following is a demographic profile of the people that registered at the public demonstrations:

	Woodstock VT	Stowe VT	Westmore VT	Rochester VT	Total	%
Landowner	86	68	91	75	320	32
Forester	21	59	12	52	144	15
Logger	20	30	54	36	140	14
Trucker	2	3	14	8	27	3
Wood-Using Industry	16	13	17	24	70	7
Interested Public	56	64	97	71	288	29
Total	201	237	285	266	989	100

Registration of attendees was not at the cable yarding site but 1/8th to 1/2 mile away. Transportation was provided by a mini-bus at three of the four demonstration sites. At the registration area, attendees were given a brochure on the Vermont Cable Yarding Project and an explanation of what the project consisted of, who was doing it and why it was being done. Emphasis was placed on the purpose of the public demonstrations:

1. To show and explain how and where the system could operate.

2. To gather comments, questions about and recommendations that might improve the system and its operation.

After completing the registration form, the attendees walked or were transported to the cable yarding site, where Gerry Hawkes gave an overview of the project, description of its components, how it was fabricated and designed capabilities, and showed how and where the system operates. In addition, he explained how the system had worked in other locations and changes that had been made to the system since its inception.

After hearing Hawkes' presentation and seeing the Vermont Cable Yarder operate, most of the people attending returned to the registration area to thank us for giving them an opportunity to see the system, make comments and ask questions. The following are the comments, questions and recommendations most frequently received:

1. I don't see the need to prebunch the material to be removed.

2. I think it's a great idea.

3. Can I rent or lease the system?

4. Where can I get someone to cut my woodlot using a system like this one?

5. The system won't take the place of skidders and bulldozers.

6. You should have a hydraulic winch to tighten the skyline.

7. You should use cable chokers with slides and have a man on the landing to unhook them. This would eliminate prebunching the material and they would be less apt to get caught on the skyline like the chain chokers were doing.

8. Your production would be higher if you had a professional logging crew operating the system.

9. The system really needs a loader on the landing.

10. You should be bringing out tree length material.

11. The system should be bringing out more material on each hitch.

12. The system will never work.

13. I'm impressed with the type of work the system can do. That ground was really steep.

14. If you can increase the production and make it pay, I think you'll see more of them.

15. It appears to take a lot of people to run it.

16. The system looks good but it isn't big enough to fit into my operation.

17. I'm amazed at how little damage to the trees left and how little soil disturbance there was.

18. I don't think you should be cutting the trees once the cable is up. Someone could get hurt if a tree hit the cable.

The large attendance at these demonstrations is attributed to the interest generated by the publicity we received from the news media. News releases were sent to all newspapers and radio and television stations serving the state. The releases were followed up by personal contact to the media serving the area where the demonstrations were being held, providing additional information on the project. The news releases appeared in most of the newspapers and were heard over many radio stations. In addition to using the releases, the media provided feature articles in newspapers and conducted interviews for the radio and television networks. We received additional publicity through articles written for trade magazines, RC&D newsletters and the Vermont Forest Exchange and Information Bulletin.

All in all, we feel the demonstrations were a success and appreciated by those in attendance. The success could not have been achieved without the assistance and cooperation of the following:

1. Woodland Fuels, Inc.

2. Vermont Department of Forests, Parks and Recreation.

3. USDA, Forest Service.

4. Northern Vermont Resource Conservation and Development Area.

5. News media serving the state.

SUMMARY

Throughout the life of the project, the Vermont Cable Yarder showed it was capable of removing timber:

1. from any type of terrain, including (slopes in excess of 50 percent, over ravines and streams);

2. in any manner, uphill, downhill and cross-slope;

3. with little or no soil disturbance;

4. with little residual stand damage; the recorded damage was within acceptable limits especially when considering the steepness of the slopes and the type of terrain the yarder operated on;

5. safely;

6. in excess of one cord per hitch.

It is felt that the Vermont Cable Yarder could become a useful harvesting tool in the Northeast if the volume per turn can be increased to 45 cubic feet and the operation delays and set-up times can be reduced, thereby increasing the system utilization rate about 55 percent.

RECOMMENDATIONS

The efficiency of the Vermont Cable Yarder could be improved a number of ways.

1. Reducing the set-up times. This might be accomplished by:
   a. having a powered skyline reel that could raise, lower and tension the skyline; and
   b. additional training of the crew on set-up and take-down of the system.

2. Using suitable size cable chokers and slides to eliminate some of the operational delays such as:
   a. choker chains caught on working lines and skyline;
   b. choker release failures;
   c. chokers caught in log pile;
   d. adjusting choker chains;
   e. bunching of loads; and
   f. reducing the cycle time by having the chokers set on the material being removed before the carriage returns to the woods. Also, by using cable chokers and slides, more stems could be put on the hitch, thus enabling an average volume per turn to be increased from 15 to 45 ft.^{3}.

3. Having a loader and a man on the landing to unhook the chokers and move the tree length material from the skyline would:
   a. eliminate the large pile buildup under the skyline by reducing the delay time related to this problem;
   b. allow better utilization of the material by having an experienced and knowledgeable man bucking the tree length material into different product classes such as veneer, sawlog, and firewood; and
   c. allow the loader to put the bucked material in different product piles away from the skyline where trucks could be loaded without interfering with the yarding operation.

4. Extensive training of crew in application and operation of cable systems.

5. Becoming familiar with components and capabilities of existing systems and keeping informed of developments of new cable systems for possible modifications that could improve this system.

6. Having cutters knowledgeable and proficient in the art of directional felling of trees.

GLOSSARY

Block — a metal bracket containing a sheave which changes the direction of a wire rope.

Bunch — to assemble logs together to form a load for subsequent transport.

Chaser — a person responsible for unhooking turns of logs at the landing when self-releasing chokers are not used.

Choker — the cable or chain fastened around logs being yarded.

Chopper — a person responsible for felling and limbing trees.

Corridor — a straight path through the harvest area along which the skyline is strung.

Decking — the piling of logs at the landing by the yarding machine.

Deflection — the sag of a wire rope when stretched over an unsupported span.

Fairlead — rollers or sheaves which guide a wire rope onto a winch drum.

Gravity Shotgun — the use of gravity in steep uphill logging to return an empty skyline carriage to the woods.

Haul-Back — the working line which pulls the haul-in line with a carriage or chokers back to the woods.

Haul-In — the working line which pulls in a turn of logs. The term mainline has not been used since both the haul-in and haul-back lines are the same size and are interchangeable.

Highlead — a cable logging method which uses only haul-in and haul-back lines and thus drags turns along the ground causing a great amount of site disturbance.

Landing — an area, usually near a road, where turns of logs are decked at the end of each yarding cycle.

Lateral Yarding — the winching in of turns from either side of a skyline corridor.

PTO — the "Power Take Off" on the rear of agricultural tractors.

Running Skyline — a cable logging method in which both the haul-in and haul-back are run down the same corridor and tension is maintained between the two lines with the carriage riding on its own haul-back.

Setting — the area yarded from one set-up of the yarder.

Sheave — a grooved wheel used to change the direction of a wire rope, or which supports a weight traveling along a wire rope.

Skyline — the wire rope which serves as a track and support for a carriage.

Standing Skyline — a skyline which remains up and tensioned during the normal course of yarding.

Tagline — a cable which can be quickly attached or detached to another.

Tail Tree — a tree at the back end of a corridor which supports a skyline.

Turn — the load or hitch of logs transported from the woods to the landing with each cycle of the yarding system.

Wire Rope — (the terms cable and line are used synonymously) — strands of small wire wound together in a variety of arrangements to form a flexible steel rope many times stronger and wear-resistant than fiber rope.

Yarding — the initial movement of timber from the stump to the landing.